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James Allan Hudson
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SECTION 30 (1977 ACT) APPLICATION FILED 11/8/04

Patents ADP number *(if you know it)*

8652851001

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4. Title of the invention

Visually overloaded keyboard.

5. Name of your agent *(if you have one)*

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Text input for Text input and other portable devices

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1 Introduction

This paper considers the problems associated with handheld text input. It proposes the application of integrated superimposed animated graphical layering, or, more specifically, *visual overloading*, combined with gestural interaction as illustrated in Belge et al (1993), Ishantha and Suguru (1995) and Silvers (1995). I argue that this approach can help to solve the problems of text input, especially for devices with limited display real estate. However, I also argue that the approach can be used for touch screen devices in general.

This paper examines some of the popular approaches to text input, some of these being currently under development. The paper then goes on to identify and discuss the individual features and difficulties of the PDA text input problem as demonstrated in Kamba et al (1996), Long et al (1997) and Masui (1999). Finally, I suggest a novel approach that involves the application of visual overloading. This takes the form of multiple layers of control elements, which make up the layered-keyboard are placed over a text panel. A control from one of the layers within a region of the keyboard can be selected with an appropriate but simple gesture, thus disambiguating between competing controls. This permits a larger population of control elements with an adequate degree of redundancy, yet without compromise to the size of control elements or inputted text pane.

2 Problem Domain

All proposed solutions to the handheld text input problem fail to acknowledge the true obstacles of preserving portability and compactness, ease and convenience of interaction and the deft conservation of screen real estate. Before these factors are addressed, the following section outlines some of the more successful approaches.

3 Background

In order to illustrate the problem of text input for handheld devices, this section critically examines a number of text input solutions.

3.1 Plug-in Keyboards or Built in Keyboards

Plug-in keyboards would seem to offer a solution to the problem of easily entering text on small devices. However, this could be regarded as being like buying an anchor to make your PDA behave like a desktop. The integration of a usable keyboard into the design compromises the necessary limit on size and ergonomics of use, not to mention the portability of the device.

3.2 Clip on Thumb Keyboard & Overlays

Clip on keyboards may seem to provide a usable text entry facility for small devices, at least on physical grounds. However, they do add bulk, and thus adversely affect the trade-off between size, portability and practicality.

An alternative to the clip on is the *overlay keyboard*. Though these do not increase the size of the device, they do have usability implications. The overlay is essentially no different from a soft keyboard (discussed below), and actually is a very expensive sticker that permanently renders the utility of a portion of the display for text input only, restricting the use of an already limited resource.

3.3 Soft keyboards or Dialogue Driven Input Approaches.

The soft keyboard is not really too different from the clip-on keyboard, except it is implemented as a graphical panel of buttons rather than a physical sticker. The soft keyboard has the added hindrance of consuming screen display area, as does the overlay approach. However, the soft keyboard does permit the user to free-up display area when required.

3.4 Standard and Full Screen Keyboards

The soft keyboard seems to be the most commonly accepted solution; see Kamba et al (1996), Kölsch and Turk (2002), MacKenzie and Soukoreff (1999), MacKenzie and Zhang (1999). However, it is a solution that is greedy in terms of screen area. Two examples can be used to illustrate the trade off between redundancy, ergonomics of use and visible display. Firstly, a full screen keyboard offers direct input with no stylus. Secondly, the standard split screen keyboard removes redundancy for the sake of visible display, yet its small size results in the need to use an additional device, such as a stylus, as it becomes difficult to use dextrously with the fingers.

One approach based on the standard keyboard and akin to one I propose is one that uses a static soft keyboard placed in the background of the display text. A letter is selected by tapping the appropriate region in the background.

This solution permits manual input and does preserve some screen real estate. A drawback is this approach is limited to one layer, necessitating a cumbersome need to explicitly switch between numbers, punctuation and other lesser used keys. Another drawback is the user has to avoid obscuring the keyboard with carefully selected input text. Moreover, the reliance on point and click interaction is limiting; the approach would benefit from the addition of gesture interaction to promote a greater degree of redundancy and richer level of interaction.

3.5 Statistically Optimised Single Digit Keyboard

A lot of effort has been expended to improve the soft keyboard approach, however these attempts are still subject to the drawbacks already describe with this approach, moreover they are subject to a learning overhead imposed by remodelling the keyboard layout.

On the Unistroke keyboard Hunter et al (2000); Mankoff and Abowd (1998); Zhai et al (2000), all letters are equidistant, thus eliminating excessive key homing distances.

The Metropolis keyboard Zhai et al (2000) is another optimised soft keyboard layout, statistically optimised for single finger input, improving efficiency by placing frequently used keys near the centre of the keyboard.

Both approaches can be effective, but both impose a learning overhead due to a new keyboard layout. The user must expend considerable effort to become familiar with the keyboard for relatively slim rewards, not to mention the overhead inherent with soft keyboards, such as the consumption of screen real estate.

3.6 Handwriting Recognition

Handwriting recognition was for some time the holy grail of PDA text input solutions. However, evaluation revealed that gesture recognition for text input is balky and slower, some 25wpm at best, than that of, say, other less sophisticated approaches, such as the soft keyboard Dix et al (1998).

The obvious problem with handwritten input is the need to draw each letter of each word, etc., whereas the keyboard solution requires merely the pressing of a button. In addition to this difficulty, as with the standard soft keyboard, the text input requires the use of a stylus, thus occupying the user's free hand (i.e., the need to hold the PDA) when entering text.

3.7 Alternative Approaches

I now consider alternative, less well known, solutions to the problems of text entry for small devices.

3.8 Virtual Keyboards

One alternative approach to PDA text input is the use of a *virtual keyboard*. This uses hand-mounted sensors that allow the user to type on any surface as if it were a keyboard.

The device features two hand-mounted sensors that record biometric data from the hands and convert it to the corresponding keystroke, thus permitting the operator to use any surface as a keyboard. A similar approach is outlined in Goldstein and Chincholle (1999).

Sensors in the hand units measure the finger movements, while artificial intelligence techniques and a language processor determine appropriate keystrokes or mouse movements. This novel approach is an intriguing solution. The main problem is the need to carry around two mittens that are nearly as big as the PDA itself, and which contribute to the awkwardness of text entry. Finally, a visual representation of the virtual keyboard must be provided. Thus, the solution does not effectively release screen area for alternative uses.

3.9 Dynamic Dialogues

Dynamic dialogues illustrated in Ward et al (2000) are an innovative data entry interface incorporating language modelling. They are driven by continuous two-dimensional gestures, where the user selects strings of letters as they progress across the screen. Letters with a higher probability of being found in a word are positioned close to the centre line.

Though the dynamic dialogue approach makes use of 2D gestures, these are supported by affordance mechanisms and they have been kept simple for standard interaction, making them readily learnable.

Users reach writing speeds of between 20-34 words per minute, which is slow when compared with typical ten-finger keyboard typing of 40-60 words per minute. Moreover, a large percentage of the screen is taken up with the input dialogue, even more than with a soft keyboard.

4 Evaluation of Handheld Text Input.

The major problem with many text input solutions is the lack of investigation into the true problem of PDA text input. The important thing is not the *mechanism* for inputting text per se, but rather the constraints on the size of a text input panel that reduce the free display region of a screen. For example, with dynamic dialogues, the

text panel for a text entry device can be reduced to as little as 17% of the screen. It is suspected that a dedicated input panel taking up the same 65% of the screen as the dynamic input panel would result in a large, elaborate soft keyboard, which would probably provide good input rates, with respect to Fitt's law Sears et al (1993).
I next discuss the requirements for, and constraints on, the design of text input devices for handheld devices

4.1 Ease of use
In order to free up as much screen display as possible, input dialogues are reduced in size. In order to minimise the display area used, designers resort to using menus. Seldom used commands inevitably feature in submenus, which leads to an awkward, slow, and cumbersome interaction approach (Kamba et al, 1996).

4.2 Unnecessary Interaction Aids.
Pointers, such as a stylus, clip on keyboards and data gloves, impede device usability. To interact with the device the user must either don the interaction accessory or, say, pick up a stylus, which in the case of many portable devices, ties up both hands Goldstein and Chincholle (1999).

4.3 Learning and Skill Acquisition Overhead
Many small device text input approaches are not easily learned, consider in MacKenzie and Soukoreff (1999); MacKenzie and Zhang (1999). The use of 2D alphanumeric gestures is a good example of such an approach.

5 Design Heuristics

Drawing from the evaluation of text input solutions a definition of the design considerations can be constructed, permitting the development of a fresh and expedient solution, rather than, further optimising on approaches that fail to address relevant issues such as screen real estate or convenience of use, for example the inherently flawed optimisations of the conventional soft keyboards
Consideration of the contributing factors in the design of interaction models for handheld and mobile devices leads to the following design requirements:

- We should not need to rely on additional interaction aids, e.g. Stylus, as these are detrimental to the portability and ergonomic effectiveness of the device.
- We should seek a good balance between redundancy in input device features and availability of display area.
- The device should reflect an effective trade-off between display area, size of elements in the input panel, and usability.
- It should be easy to learn to use the techniques (MacKenzie and Soukoreff, 1999).

In view of the above requirements, I now discuss myproposed approach to the problem of text input for small devices.

6 Animated Transparent Layers with Gesture Interaction

Transparency is commonly used to optimise screen area, which can often be consumed by menu or status dialogues. Bartlett (1992) and Harrison (1995) consider that the conventional approach of using a layer of transparency to display a menu is done at the cost of obscuring whatever is in the background. This is not actually visual overloading, but rather a compromise between two images competing for limited

display area. In fact, an underpinning feature of the scheme described by Harrison (1995) and, Harrison and Vicente (1996) is the investigation of levels of transparency to optimize this compromise.

Visual overloading is different from the use of transparency in graphical layering. Overloading is the use of techniques and guidelines such as dynamic signatures, illustrated in Belge et al (1993), Ishantha and Suguru (1995), Johansson (1973) and Long et al (1997) to allow the user to selectively view two or possibly more visuals simultaneously, a sort of intensive farming of screen real estate rather than the facilitation of a compromise.

The incorporation of simple gestures, explored in Long et al (1997) and Rakowski (2001), is an elegant solution that avoids the errors that arise in the recognition of more elaborate gestures, while offering additional context required beyond that of the restricted point and click approach. However, gestural input is partly a consequence of implementing visual overloading, since it is necessary to resolve issues of layer interaction. To avoid the overhead of manipulating layers, such as moving them about to address, for example, elements or widgets which are beneath a layer, gestural interaction is used to provide the necessary context.

7 Proposed Solution

My proposed approach to text entry on small devices uses the visual overloading techniques. These techniques consist of transparent images, as described in Bartlett (1992), Cox et al (1998) and Harrison and Vicente (1996) with the addition of dynamic signatures, as demonstrated in Belge et al (1993), Bier et al (1994), Ishantha and Suguru (1995) and Silvers (1995). The use of animated transparencies permits the superimposing of layers of input dialogues over the output text, without compromise to the coherency of competing layers (see Fig. 1). In this way, an agreeable balance between display area and input dialogue can be established, as discussed in Kamba et al (1996).

Fig. 1. A mock up of the proposed solution[1], a superimposed Skipnum keyboard on a layer of text[2]

To operate the keyboard (see Fig. 2), the user makes very simple gradient gestures, although the approach can make use of more elaborate gestures for more involved interaction, as in Long et al (1997). To select a letter, a gradient stroke that ends or starts over the selected button is performed. The dynamic motion or signature of the keyboard elements assists in affording the direction of the gesture. This use of gesture permits a simple solution to accessing redundant controls without the overhead of the outlay of extra display area or cumbersome window manipulation, as discussed in Rakowski (2001). For example the keyboard can be intensively populated with layers of letters, numbers and punctuation. An upward oriented gradient gesture would select a letter and a downward gesture selects a number. Simply tapping on the keyboard selects the appropriate punctuation, or a gesture of the letter "C" could be used to activate a command that displays a ",", this could be either a select region of the screen or anywhere, making it a global command.

Fig.2. An element of an overloaded button is selected by drawing a gradient stroke that ends over the button. The angle supplies the context indicating which element is being selected. "A" would be selected with a left terminating gesture, while "<space>" would be selected with a downward stroke.

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[1] The number of layers in the illustration is restricted for clarity, however it supports multiple layers, of up to four.
[2] Although it cannot be seen in print, the layer of letters, when in motion, stand out against the background and appears somewhat more coherent.

8 Evaluation

The above approach leads to several benefits, as now discussed.

- There is no reliance on additional interaction aids, as the dialogue elements are large enough to support manual operation.
- The keyboard is somewhat less awkward to use, since it is large enough to interact without using styli, and so on, without compromising redundancy or screen real estate.
- The approach reflects an effective combination of redundancy in input device features and availability of display area.
- Finally, the approach provides an adequate trade-off between display area, size of elements in the input panel, and usability.

As has been illustrated, my visual overloading technique solves the text entry problem without imposing significant overhead. Moreover, with appropriate training, a user can input text at rates comparable to that of standard soft keyboards (i.e., around 40wpm). What we lose by having to make a gesture is gained through having a larger area to select (cf. Fitt's law). Moreover, the gesture solution implemented is simple, and is relatively error free, and does not suffer from the computational overhead of the more elaborate gesture recognition approaches.

9 Conclusion

This paper has illustrated the constraints on and issues relating to, the development of text input devices for mobile and wearable devices, as illustrated in Dunlop and Crossan (1999) and MacKenzie and Soukoreff (1999). A solution to the problems and shortcomings of existing schemes was proposed. A prototype system, making use of gestures and visual overloading, was also described. It was argued that this prototype makes effective use of screen area, preserves the portability of the device, and does not suffer from the computational overheads of more complex gestural interfaces.
My current work involves investigating the application of my techniques to support text input for Databoards, public information Kiosks (considered by Christian and Avery, 1998) and one-finger input for very small devices, such as wearable devices (Masui, 1999). I are exploring the effectiveness of visual overloading itself, and seeking to improve touch screen interaction, among other things. I also intend to explore the use of techniques in a predictive text application.
Finally, I recognise that our future research will benefit from an investigation into theories of perception. Such work may help us to minimise, and govern the effects of, *visual rivalry*, perhaps by introducing 3D elements, as discussed in Pourang (2000a and 2000b), and dynamic shading and elements, studied by Bier et al (1994), and McGuffin and Balakrishnan (2002).

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Abstract

Visually Overloaded Keyboard

Text input with a PDA is not as easy as it should be, especially when compared to a desktop set up with a standard keyboard. The plethora of attempted solutions to the text input problem for mobile devices provides evidence of the difficulties, and suggests the need for more imaginative approaches. We propose an approach that optimises on the ability of humans to effortlessly distinguish between animated transparent overlays. Our approach permits the intensive population of a display through the layering of control elements. Moreover we can limit population of these controls by overloading their functionality with gesture interaction. This we achieve without compromise in size of the inputted text pane or to the size of control elements.

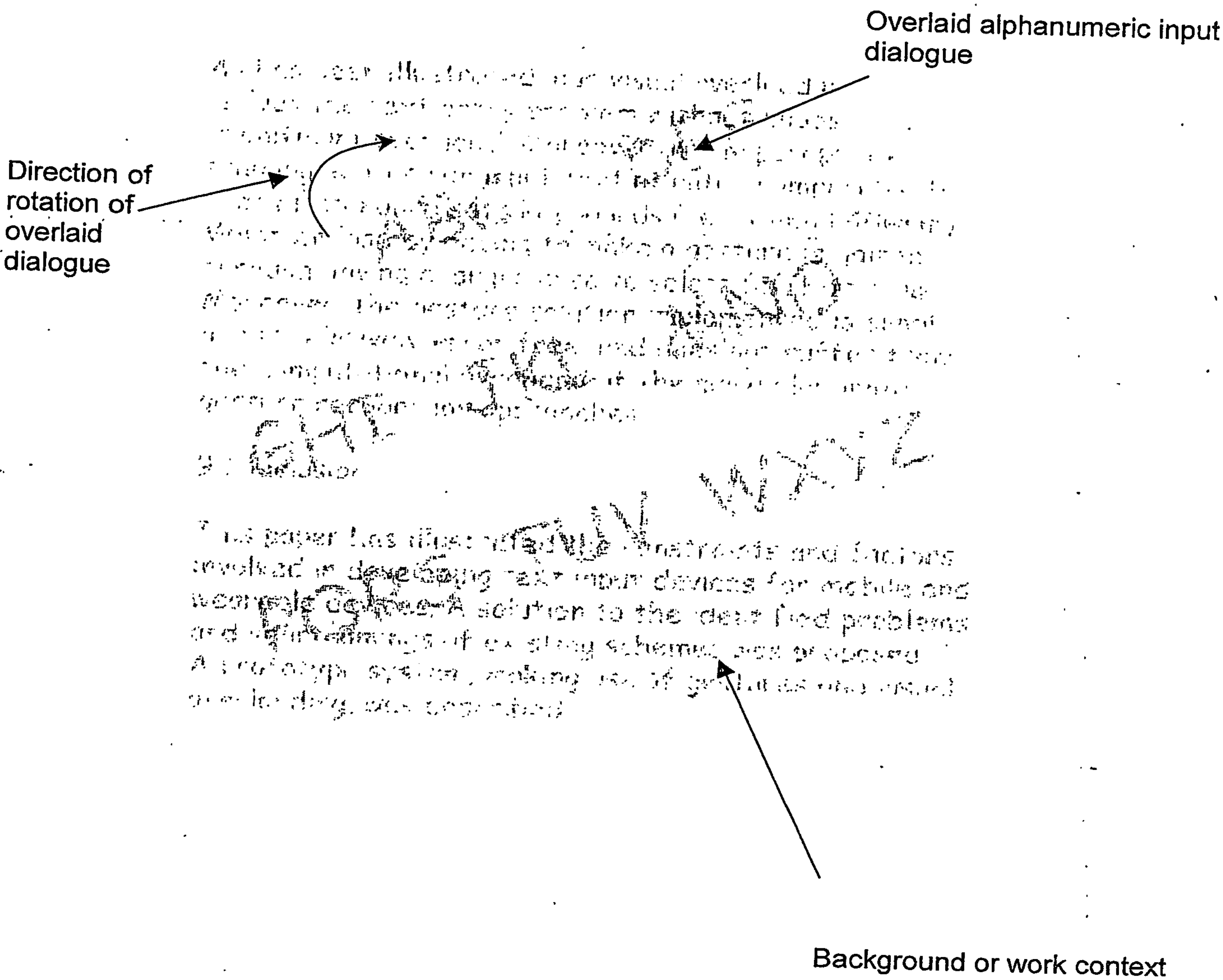

Fig. 1. A mock up of the proposed solution[1], a superimposed Skipnum keyboard on a layer of text[2]

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[1] The number of layers in the illustration is restricted for clarity, however it supports multiple layers, of up to four. or more

[2] Although it cannot be seen in print, the layer of letters, when in motion, stand out against the background and appears somewhat more coherent.

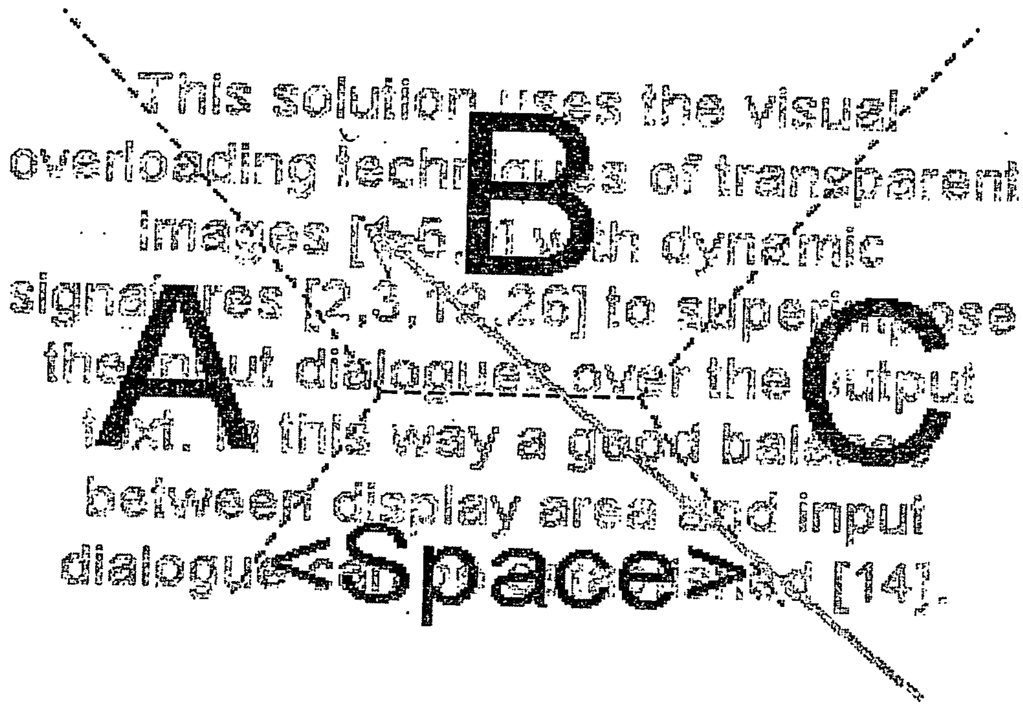

Fig.2. An element of an overloaded button is selected by drawing a gradient stroke that ends over the button. The angle supplies the context indicating which element is being selected. "A" would be selected with a left terminating gesture, while "<space>" would be selected with a downward stroke.